Title: Round and Round and Round We Go!

Brief Overview:

Many CBL (Calculator-Based Laboratory) lessons have been created using the motion detector and straight motion. This lesson allows the student to investigate graphs of non-linear motions such as a circle, ellipse, or figure-eight pattern using the CBL or CBR (Calculator-Based Ranger). The student will also investigate the concepts of amplitude and period.

Links to Standards:

- **Mathematics as Problem Solving**
  The students will use problem-solving approaches to interpret graphs of non-linear functions.

- **Mathematics as Communication**
  The students will express their understanding of the lesson in written and oral form.

- **Mathematics as Reasoning**
  The students will demonstrate their ability to reason inductively by making conjectures.

- **Mathematical Connections**
  The students will understand the connection between geometric shapes and graphical representations.

- **Functions**
  The students will translate between geometrical, graphical, and descriptive representations.

Links to Maryland High School Mathematics Core Learning Goals:

- **1.1.1:** The student will recognize, describe, and extend patterns and functional relationships that are expressed numerically, algebraically, and geometrically.

- **1.1.2:** The student will represent patterns and functional relationships in a table, as a graph, and/or by mathematical expression.

- **1.1.4:** The student will describe the graph of a non-linear function in terms of the basic concepts of maxima and minima, roots, limits, rate of change, and continuity.

- **2.2.3:** The student will identify and use inductive and deductive reasoning.

Grade/Level:

Grades 8-10 (Algebra I, Algebra II)

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- Using CBL with Motion Detector probe or CBR
- Executing programs on the graphing calculator

Objectives:

Students will:

- recognize, describe, and extend patterns and functional relationships that are expressed graphically.
- represent patterns and functional relationships as a graph.
- and describe the graph of a non-linear function in terms of maxima, minima, amplitude, and cycle/period.

Materials/Resources/Printed Materials:

- CBL with Motion Detector probe or CBR
- Overhead screen for CBL or CBR
- TI-82 or TI-83 calculator
- copies of Activity Sheets 1 and 2
- copies of Performance Based Assessment

Development/Procedures:

• The teacher will use the CBL Motion program, CBL Hiker program, or CBR Ranger program (under the Applications menu) to demonstrate to the class how the CBL works (see Teacher Notes). Using the Motion Detector probe, the teacher should have several students physically generate graphs of different functions (i.e. lines, curves, positive slope, negative slope...)

• The teacher will guide the class through the CBL D/T Match program (or CBR Ranger program) using the Motion Detector probe (or Ranger). The teacher should lead the class in a discussion of the different graphs generated by the CBL/CBR (i.e. minima, maxima, rate of change, continuity...)

• The students will complete Activity Sheet 1.

• The students will complete Activity Sheet 2.

• After completing the activity sheets, the students will use CBL to model examples #1-4 on Activity Sheet 2. The students will sketch the graphs generated with the CBL in the "Actual" graph column of the activity sheet.

• The teacher will use the Teacher Notes Sheet to lead the class in an analysis discussion of the activity.

• The students will conclude the activity by taking a performance based assessment.

Performance Assessment:

• Activity Sheets 1 and 2 can be graded based on teacher preference.

• Performance based assessment will evaluate the student's mastery of the concepts.

Extension/Follow Up:

- Have the students analyze the graphs generated by walking circles with different radii.
- Use two CBLs with overhead projectors to simultaneously generate the same graph using two different motions (i.e. one with straight motion and one with circular motion).
- Have students bring in remote control cars to use in place of students walking the pattern.

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TEACHER NOTES SHEET

• CBL/CBR Notes

1. The teacher has the option of using the CBL Motion Program, the CBL Hiker Program, or the CBR Ranger program. The Motion program allows the user to select the number of seconds for data collection, whereas the Hiker program is set at eight seconds. If using the CBR instead of the CBL, you must use the Ranger program. An advantage of the CBR is that the entire unit can be easily hand-held and aimed at a wall to perform the experiment. This data collecting system usually produces much better graphs than the CBL.

2. The experiment can be performed in one of two ways:

a) The CBL and Motion Detector probe can be stationary while the person walks the specified patterns (see CBL Guidebook).
b) The walker can hold the CBL and Motion Detector probe while walking the given path with the detector facing an object-free wall.

3. Make sure after hooking up the CBL and Motion Detector Probe that there are three dashed lines appearing on the CBL screen. This indicates that the proper connection has been made.

• Suggestion for comparing Activity Sheet 2 results:

1. Give each group and overhead transparency of Sheet 2 to copy graph results. Layer each group's answers on the overhead to compare the results.

2. Have each group display answers on board. Discuss results.

• Discussion Questions:

1. Why can the graphs of circles and ellipses also be generated with straight line motion?

2. What pattern do you see in each of the graphs in Activity Sheet 2? (discuss amplitude, minima, maxima)

3. From the graph how can you tell where the person begins to retrace the shape? (discuss period/cycle)

Activity Sheet 1- Straight Motion

Name_____

Use the graph above and your knowledge of distance/time graphs to answer the following questions.

1. What does it mean when the graph starts high on the y axis?

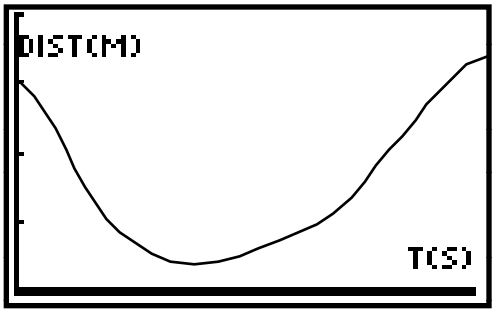
2. What does it mean when the graph ends high on the y axis?

3. What does it mean when the graph is continually increasing?

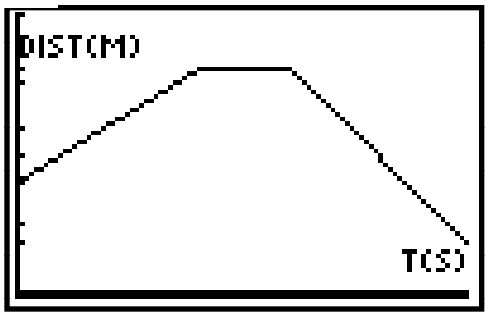
continually decreasing?

4. Describe the situation portrayed by the following graphs.

A)

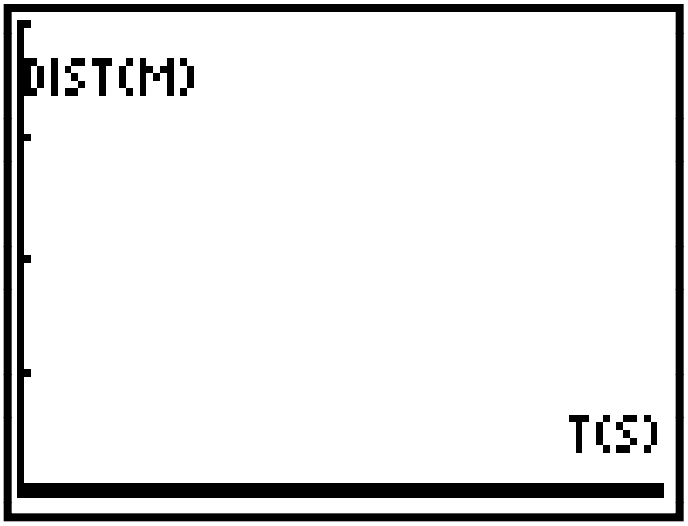


B)



5. Sketch a graph for the following situation:

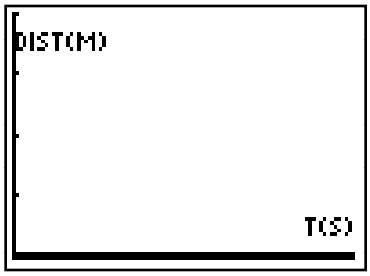
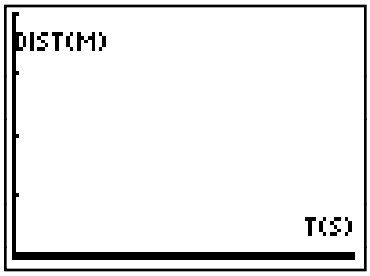
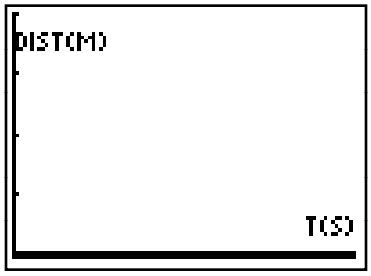
A person begins 10 units away from the motion detector; in the next 3 seconds he walks 5 units toward the motion detector; he stops for 2 seconds, and quickly runs away from the detector.



Activity Sheet 2 - Circular Motion

Name _____

Using your knowledge of distance/time graphs, sketch graphs for the following situations. The starting point for each description is approximately 3 units in front of the motion detector.

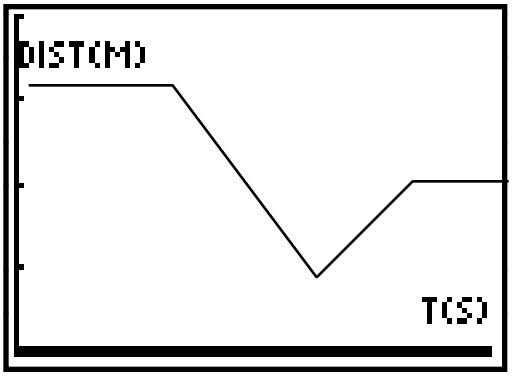
Description	Prediction	Actual
1. Walk in the form of a circle with an approximate radius of 1 unit.		
2. Walk in the form of an ellipse(oval), approximately the same size as the circle in description one.		
3. Walk in the shape of a vertical 'figure 8', as shown.  motion detector		
4. Walk the shape of a horizontal 'figure 8', as shown.  motion detector		

Performance Based Assessment

Name_____

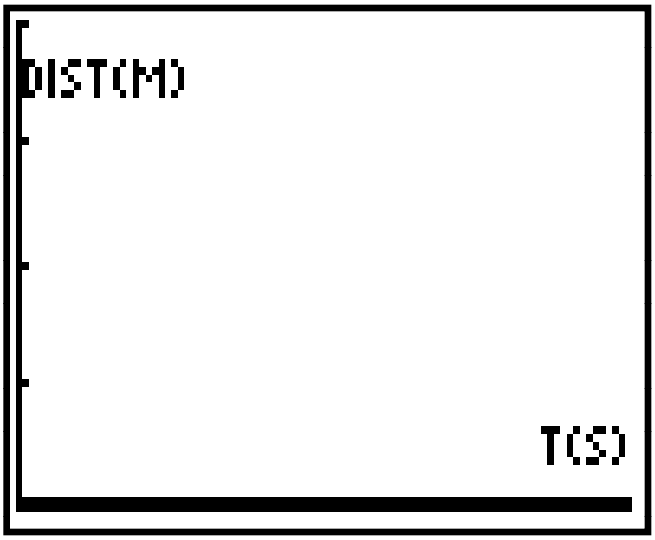
1. In a distance-time graph, what does it mean when the graph starts low on the y axis?

2. Describe the situation portrayed by the following graph:

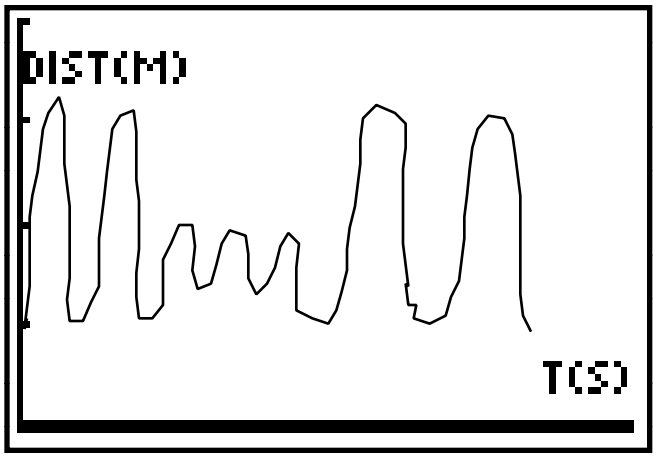


3. Sketch a graph for the following situation:

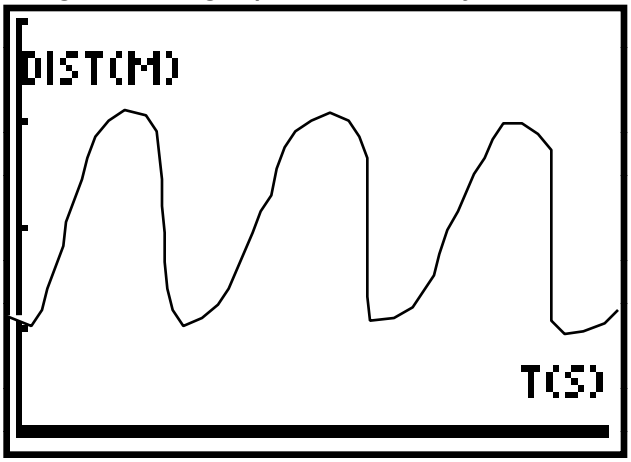
A person stands 2 units from the motion detector, walks away from the detector for 4 seconds, stops for 2 seconds, and walks back towards the detector for 2 seconds.



4. What is the maximum distance that the person walked away from the starting point?



5. The following graph describes the motion of a person walking in circles. According to the graph, how many circles did the person complete?



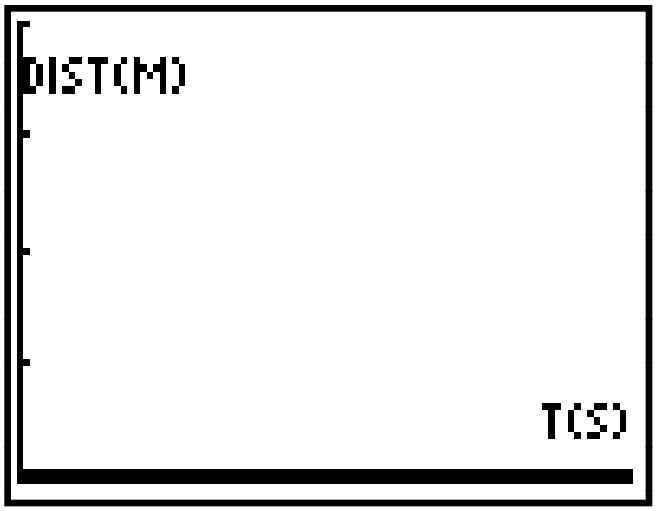
6. Choose or create a geometrical shape (other than a circle, ellipse, or ‘figure 8’) you would walk in front of the motion detector.

A. Sketch the path of the shape you would walk.

motion detector 

B. Using your previous experiences, describe what the graph of your path would look like.

C. Using the CBL or CBR, walk the path you described. Sketch and/or print the graph that your figure generated.



7. Compare your answers to 6b and 6c. Was your prediction accurate? Why or Why not?

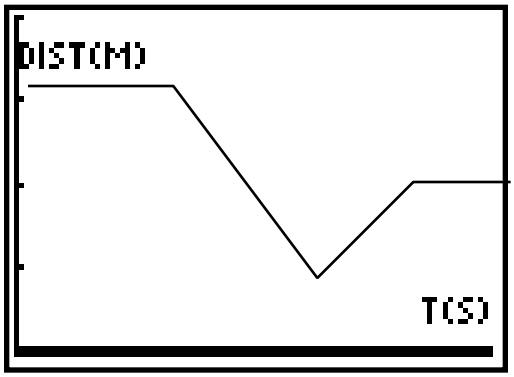
EXEMPLARY RESPONSE
Performance Based Assessment

Name KEY

1. In a distance-time graph, what does it mean when the graph starts low on the y axis?

The person is standing a short distance from the motion detector.

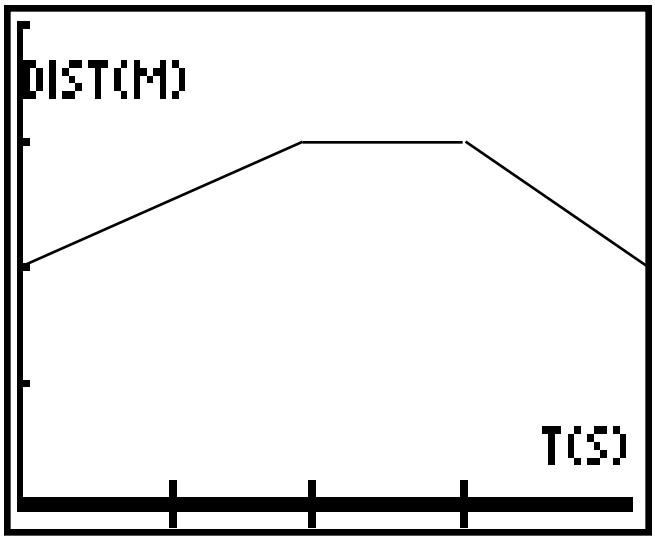
2. Describe the situation portrayed by the following graph:



A person starts 3 units from the motion detector. He stands still for a few seconds and walks 2 units toward the detector for a few seconds. He then walks at a slower rate back 1 unit and stops. He then stands still for the remaining time.

3. Sketch a graph for the following situation:

A person stands 2 units from the motion detector, walks away from the detector for 4 seconds, stops for 2 seconds, and walks back towards the detector for 2 seconds.

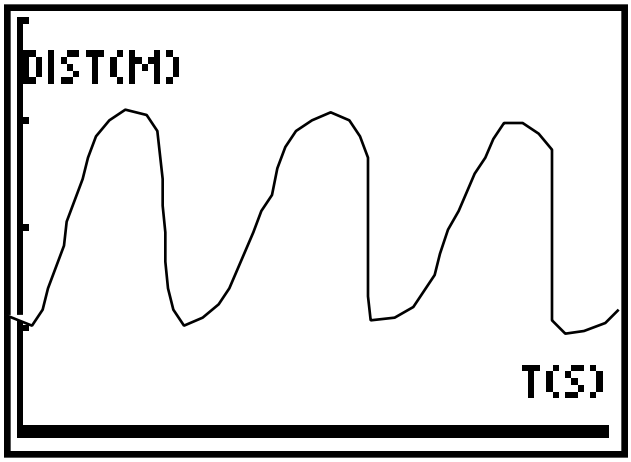


Sample Graph
(Answers may vary)

4. What is the maximum distance that this person walked away from the starting point?

2 units

5. The following graph describes the motion of a person walking in circles. According to the graph, how many circles did the person complete?



3 circles

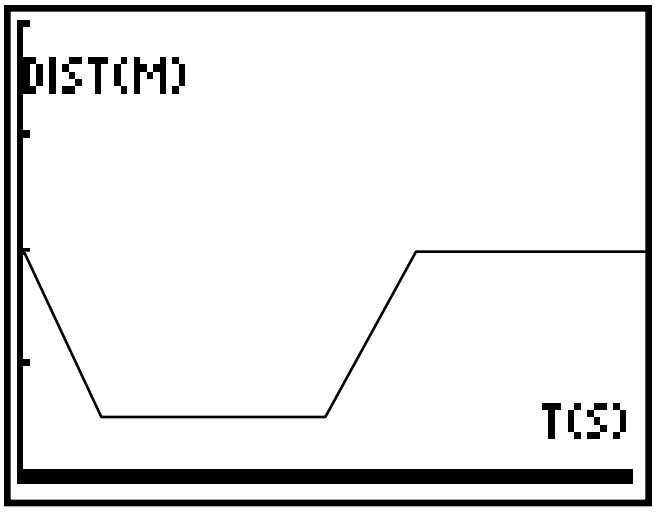
6. Choose or create a geometrical shape (other than a circle, ellipse, or 'figure 8') you would walk in front of the motion detector.

A. Sketch the path of the shape you would walk.

B. Using your previous experiences, describe what the graph of your path would look like.

Starting 2 units away, the graph would decrease, stay parallel (horizontal) for a few seconds, then the graph would increase again, stop at 2 units away and become horizontal again.

C. Using the CBL or CBR, walk the path you described. Sketch and/or print the graph that your figure generated.



7. Compare your answers to 6b and 6c. Was your prediction accurate? Why or Why not?

Answers may vary